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カナダ・Lumby Lake地域（30億年前）堆積岩の地質学的地球化学的研究

Geological and geochemical study of Archean sedimentary rocks of the 3.0 Ga Lumby Lake Group, Canada

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Large uncertainty exists for the ecosystem at ca. 3.0 Ga Earth surface environments. In particular, it is uncertain (1) if phototrophic microorganisms were active and (2) where methanogens and methanotrophs were active. In order to answer those questions, sedimentary rocks of the Lumby Lake Group were studied. The Lumby Lake Group is located in the Atikokan area, Ontario, Canada.
Ultramafic-mafic volcanic rocks, including pillow and massive lavas and hyaloclastite were dominant in the area. In the studied area, marine sedimentary rocks, including banded iron formations (BIFs), were also observed. Black shales were spatially associated with the BIFs making alternate layer. Sandy turbidite was thinly distributed around BIF horizons.
Petrographical and geochemical analyses were performed on the BIFs and black shales. The BIFs were composed of alternating magnetite-rich and silica-rich layers. Both layers commonly contained Fe-rich amphiboles (grunerite and actinolite). Grunerite appeared to be formed by a reaction between quartz and siderite. Apatite was also found in magnetite-rich zone. This also support that a primary phase before magnetite was hematite (or goethite) because phosphates are easily adsorbed on Fe-(hydro) oxides. These observations may suggest that the primary Fe-bearing minerals in the BIFs were both siderite and hematite. The black shales contain 0.2 to 2.3 wt% of total organic carbon and 1.1 to 24.9 wt% of Ssulfide. These shales also contain two types of pyrite: fine-grained layered type and nodular type. Layered deposition of pyrites indicates that these pyrites were formed syngenetically with other matrix materials. On the other hand, the nodular pyrites were composed of aggregates of pyrite and other sulfides (e.g., chalcopyrite, sphalerite and pyrrhotite), indicating that they were precipitated from later hydrothermal fluids. Therefore, alterations of the sedimentary rocks by submarine hydrothermal activities was widely recognized in the area.
The carbon isotope compositions of organic carbon in the black shales showed a bimodal distribution: -46 to -40 per mil (studied area1) and -26 to -22 per mil (studied area4). While the lighter values suggest the activity of methanogens and methanotrophs, the heavier values suggest the activity of photoautotrophic primary producer (i.e., cyanobacteria). Methanogens could have been active in this anoxic part of ocean water. On the other hand, cyanobacteria may have been active in the photic zone, producing dissolved oxygen. The sulfur isotope compositions of sulfides ranged from -2.98 to +6.70 per mil. The sulfur isotope data suggest the high flux of H_2S from

submarine hydrothermal activity. H_2S was produced by sulfate reduction. The our results suggest that both chemoautotrophic ecosystems, depending on submarine hydrothermal systems, and phototrophic ecosystems were present at 3.0 Ga. In particular, methanogens activities were constrained in very reducing bottom water environments where hydrogen from hydrothermal fluids was available.